Transmission electron microscopy of $Al_xGa_{1-x}N/SiC$ multilayer structures grown on sapphire substrates

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The potential of wide-band-gap III-V nitrides as ultraviolet sensors and light emitters has prompted an increasing amount of work recently, including the fabrication of the first UV sensors from as-deposited single crystal GaN. We have used high resolution transmission electron microscopy (TEM) to study the microstructure of two novel developments of wide-band-gap HI-V nitrides: the growth of ultra-short period GaN/AlN superlattices; and the incorporation of SiC layers into $Al_xGa_{1-x}N$ structures. By varying the relative periods in a GaN/AlN superlattice, the band gap of the composite can be tailored to lie between the elemental values of 365nm for GaN and 200nm for AIN. The group IV semiconductor, SiC, has a wide band-gap and has a close lattice match (< 3%) to $Al_xGa_{1-x}N$ for growth on the basal plane. Demonstration of epitaxial growth for $Al_xGa_{1-x}N/SiC$ multilayers would introduce a wide band-gap analog to the already existing family of III-V and $Si_{1-x}Ge_x$ heteroepitaxial growth systems. Although good quality growth of GaN on SiC substrates has been demonstrated, $Al_xGa_{1-x}N/SiC$ multilayer structures have never been grown and the interracial structure is unknown.

The layers were grown by low-pressure metalorganic chemical-vapor deposition (MOCVD) using a unique switched atomic-layer-epitaxy (SALE) procedure (as first used by Dapkus et al. for GaAs). GaN was grown on the basal-plane sapphire substrates above a thin AIN layer, which has been found to maximize the crystalline quality of the GaN film. A series of GaN/AlN superlattices (nxm where $n, m \leq 6$) were subsequently grown by SALE. High resolution TEM of cross-sections of this structure indicate that atomically abrupt superlattices can be obtained using such a growth method. These results will be discussed in the light of the optical properties of these structures.

For the growth of SiC on AIN on basal-plane sapphire, TEM shows that the carbide grows almost exclusively with the c-axis in the growth direction. However, initially repeated random twinning occurs on the basal (growth) plane. The 3-C phase emerges as the dominant polytype after about 50nm of SiC growth. We shall also present results of the subsequent growth of GaN on the carbide. The feasibility of optimizing the growth to produce $Al_xGa_{1-x}N/SiC$ superlattice structures will be evaluated.

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